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㊹ヤーン等の開繊方法

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明　細　書

1. 発明の名称

ヤーン等の開繊方法

2. 特許請求の範囲

連続的に給糸されるヤーン等を、円柱体上においてその円柱体の軸方向に振動を与えつつ、走行させて開繊することを特徴とするヤーン等の開繊方法。

3. 発明の詳細な説明

本発明はヤーン等の開繊方法に係り、詳しくは、ヤーン等をけば等を発生させることなく、十分に薄く開繊でき、高品位のシートが容易に製造できるヤーン等の開繊方法に係る。

現在、炭素繊維、ガラス繊維等の引揃プリプレグシートが種々の用途に供せられている。このプリプレグシートはヤーン等を薄く開繊すると共にシート状に引揃え、樹脂含浸したのち半硬化して製造されている。しかし、このようにプリプレグシートを製造する場合に、ヤーンの開繊に問題があり、高品位のシートを製造する

ことが困難であつて、その改善が望まれている。

すなわち、高品位のプリプレグシートとは、例えば、100 m以上の如く長尺であるとともに薄く、例えば、厚さ 0.1 mm 程度に開繊引揃えられているものであつて、しかも、このシートの各フイラメントが蛇行なく引揃えられ、目割れが無く、場合によつては樹脂の含浸率が低いことが必要である。しかし、従来法でヤーンを開繊する場合は、各フイラメントに摩擦力や集束力等が作用し、十分にヤーンを薄く拡げることが困難であり、シートとして成形後には目割れ等が生じて高品位のものを製造することは困難である。

本発明は上記欠点の解決を目的とし、具体的には、十分に薄くヤーン等を開繊でき、しかも、各フイラメントが互いにからみ合つて目割れが生じることがないヤーン等の開繊方法を提案する。

すなわち、本発明は連続的に給糸されるヤーン等を、円柱体状においてその円柱体の軸方向

に振動を与えつつ、走行させて開繊することを特徴とする。

以下、本発明法について詳しく説明する。

なお、本発明は炭素繊維やガラス繊維などの引揃プリプレグシートをヤーンから開繊して製造する場合、特に有効であるが、これに限定されることなくヤーン一般の開繊に適用できる。

まず、第1図は本発明法によつてヤーンを開繊してシート状に引揃え樹脂含浸したのち、プリプレグシートを製造する装置の一例の説明図であり、第1図に示す通り、ヤーン1は通常、給糸装置2から整経装置3を通つて開繊装置4に供給される。開繊装置4(この場合、樹脂槽9の中で開繊される)において、各ヤーン1は後記の如く十分に薄く開繊されてシート状に引揃えられ、かつ樹脂含浸されて、その後、乾燥装置5に送給されて乾燥半硬化され、そのプリプレグシートは巻取ロール6に巻取られる。

なお、第1図のように樹脂含浸は、開繊装置4を樹脂槽9の中に設け、開繊を行いつつ同時

(3)

に合成樹脂を含浸させることもできるが、また開繊装置とは別個に開繊後に含浸槽を設けて、樹脂含浸を行なうこともできる。

次に、以上の通り供給されるヤーン1を開繊装置4で開繊させる際に、例えば、ヤーン1は第2図に示す如く、円柱体7上において横方向の振動を与えつつ走行させて開繊する。このように開繊すると、フイラメント間で凝集力や摩擦力が働くことなく良好に開繊でき、きわめて薄いプリプレグシートが得られる。

すなわち、ヤーン1が張力T_1で引張られて円柱体7上で支持される場合(第3図参照)、ヤーン1によつて円柱体7はT_2の圧力で押されるため、ヤーン1にはこの反力(圧力T_2と同じ値)が作用する。このため、ヤーン1が円柱体7の一部に接触した状態で走行すると、圧力T_2ならびに反力T_3によつて例えば第4図に示す如く、横に拡げられて薄く開繊される。しかし、ヤーン1が薄くなろうとすると、その部分で各フイラメント1aにはT_3とT_4の力

(4)

が働き、T_4の力によつてヤーン1は拡がることが阻害され、更に、フイラメント1a間には摩擦力が働き、凝集力(例えば静電力、ファンデルワールス力等)も作用して、ヤーンの断面は円形状になろうとする。

要するに、ヤーン1は円柱体7の一部に接触する状態で開繊してもヤーンの張力と円柱体との摩擦力によつてある程度開繊できるが、その開繊度合は不十分で十分に薄くシート状に開繊できないばかりか、ヤーン間の結合やからみ合い等が不十分で、引揃え後においても目割れ等が生じて好ましくない。これに対し、円柱体7上においてヤーン1に円柱体の軸方向の振動、つまりヤーンに対して横振動を与えると、上記の通りの力関係が破れて、ヤーン1は良好に開繊し、薄いシート状に拡げられる。この際、各ヤーン1には円柱体7で横振動が与えられれば、何れの段階で与えてもさしつかえないが、通常は円柱体7を軸方向に摺動させ、この円柱体7の一部に接触させる状態でヤーンを開繊させれば十

(5)

分である。

更に詳しく説明すると、例えば、第4図に示す如き力関係を破つて開繊させる場合には、必ずしも各ヤーンに何んらかの振動、例えば、ヤーン送給方向の振動、つまり縦振動を与えても良好に開繊できる。しかし、縦振動では開繊の目的が達成されても、ヤーンがゆるみ易いため、ヤーン間で十分にからみ合うことがないばかりか、おさ等の整経装置のところでけばが立ち易く好ましくない。この点、本発明方法の如く、ヤーンに横振動を与える場合には、十分に開繊できるばかりか、各ヤーンがゆるむことなく一定の張力ではられる状態が維持でき、十分に各ヤーンはからみ合つて、われ目のない安定したシートが得られるとともに、けば立ちも全くない。

なお、以上の通りに開繊する場合、大気中で開繊するほか、水、合成樹脂その他の溶液中においてヤーンに横振動を与えて開繊することができる。

すなわち、上記の通りに大気中において、各

(6)

ヤーンを円柱体上で横振動を与えて開繊すると、上記の通りの力関係が破れて、各ヤーンは良好に開繊するが、溶液中であると、各フィラメント間の集束力、摩擦力は小さくなり、ヤーンは更に開繊し易く、一層薄く開繊できる。

更に、溶液中であると、仮に開繊にけばが発生しても飛散することがなく、また、溶液は一種の潤滑剤的機能を果たすため、開繊の度合は向上し、ヤーンも良好にからみ合う。

また、各ヤーンは必ずしも上記の如く単層のもとで開繊する他か、例えば、上下層の如く少なくとも2層に分けて開繊後、合層してシートに引揃えることができる。

すなわち、第5図は上下2層に分けて開繊し、その後合層してシートに揃える場合の説明図であつて、この場合は第6図に示す如く、上下各ヤーン1b、1cは個々に開繊されてから合層される。つまり、上層ヤーン1bは例えば単位ピッチP間隔をおいた状態で給糸する場合は、下層のヤーン1cは $\frac{1}{2}$ ×P（ピッチ）ずつず

(7)

らして給糸し、これらはそれぞれ各円柱体7a、7bで開繊され、上記のところと同様に各円柱体7a、7bには軸方向の横振動を与える。このように開繊すると、上層と下層の各ヤーン1b、1cが互いに入り込んで合層し、目割れ等が全くないシートが得られる。

すなわち、上下両層の各ヤーン1b、1cが円柱体7上で開繊されると、はじめは、第7図(a)に示す如く薄く拡げられるが、この薄く拡げられる部分には第4図に示す如くT_4の力が働き、拡げられるのが阻止される傾向にある。しかし、各ヤーン1b、1cの一部は互いに重なり合つてからみ合つているため、各ヤーンのT_4の力は互いに打消されてからみ合つた状態は維持され、各ヤーン間は連続し目割れが生じない（第7図(b)参照）。

また、このように複数個の層のヤーンを合層させる場合の他か、単層でヤーンを供給し、このヤーンに円柱体上で横振動を与えても、隣接する各ヤーンは互いにからみ合うため、同様に

(8)

T_4の力（第4図参照）は互いに打消されて目割れが生じない。なお、各層の開繊後は合層ローラ8によつて合層される（第5図参照）。

次に、上記の通りに開繊する場合の好適条件を示すと、次の通りである。

(1)振動数

ヤーンに円柱体上で横振動を与える場合に、通常、円柱体は1分間30～3000回程度の割合で往復動させて振動を与えれば十分である。すなわち、開繊の度合を高めるのには、振動数を高めるのが好ましいが、あまり高いとけばが立ち易くなり、この点からは上限は3000回程度が好ましい。また、30回以下になると、開繊の効果がなく、炭素繊維等のヤーン等の場合は、300～600回／分程度が特に好ましい。

(2)振幅ならびにヤーンの走行速度

まず、横振動の振巾は振動数とも関連するが、あまり大きいと設備的に問題がある他か、必ずしも開繊の効果が向上しない。このため、

(9)

1～10㎜の範囲で振動させるのが好ましく、走行速度も30～150 m/時程度が好ましい。

なお、円柱体は回転させる必要がなく、通常は回転自在に支承すれば十分であるが、固定させておいてもその目的が達成できる。

次に実施例について説明する。

実施例1

まず、ガラス繊維ER-310（Eガラス　ロービング、繊度310 Tex＝2800デニール）のヤーンを給糸装置に66本仕掛け、給糸速度100 m/時間で各糸に20g/本の張力を与えながら、ピッチ4㎜で振動開繊装置に導き、開繊装置において円柱体の軸線方向に振幅2.5㎜で400回／分の振動を与え、円柱体上でヤーンを巾340㎜のシート状に開繊した。

次に、開繊したシートを2枚のガラス板で挟み観察したところ、蛇行や凹凸もなく1枚のシートとなつており、その厚みは0.05㎜であつた。又、ガラスを挟んだままこのシートの両端を切断し、ガラス板を外いてもガラスロービング間

(10)

糸が別れることは無かつた。

実施例2

また、開繊装置において、振動する円柱体を上下二段設け、これら円柱体に実施例1と同じくガラス繊維ER-310を給糸装置から43本ずつ二段とし給糸し、上段に対し下段のピッチを1/2ずらせておのおののピッチを8mmで引き出し、給糸速度、糸の張力、振動数、振幅等諸条件を実施例1と同一条件で巾340mm、厚み0.05mmのシートを作成した。開繊したシートを2枚のガラス板で挟んで観察したところ、実施例1同様きれいにシート状となつており、両端を切断してガラス板を外してもシートの形状をよく維持しており、繊維直角方向に引張つても容易に離れることはなかつた。

なお、比較のために、上記円柱体を振動させることなく、シート状に開繊したところ、ガラスロービングは円柱体接触部では押潰された格好で一体状に見えたが、円柱体通過後はヤーン一本一本が独立して集束し、シート状と出来な

(11)

かつた。

実施例3

6000 f（フイラメント）からなる炭素繊維（4000 d、dはデニール、ただし、デニールとはg/9000 mである）のマルチフイラメントヤーンを82本を実施例1と同様に給糸装置に仕掛け、マルチフイラメントヤーン1本当り50gの張力を与えながら、100m/時間の給糸速度でこれを4.2mmピッチに引揃えて、開繊装置において円柱体に横振動を与えて開繊しシート化を行なつた。

なお、この場合、開繊装置では樹脂液を入れ、これはエポキシ樹脂（シエル化学製エピコート#828）100部を100部のメチルエチルケトンに溶解し、これに外割で5%の硬化剤（BF_3）を添加したものであつて、円柱体の振幅は5mmとし、振動数を0から300回／分まで変化させてみた。その結果は表-1に示す。

(12)

表－1

回転数（回／分）	厚み（m/m）	目割れ	蛇行	毛羽
0	0.18	全体的に発生	◎	◎
30	0.11	3	◎	◎
100	0.10	0	◎	◎
300	0.10	0	◎	◎
1,000	0.10	0	○	○
2,000	0.10	0	△	△
3,000	0.10	0	×	×

ただし、目割れ：光に透過させ、シート1m²当り巾0.1mm、長さ30mm以上の欠点数を示す。

実施例4

開繊部装置において、円柱体を上下二段設け、実施例3と同様に炭素繊維マルチフイラメントヤーンを給糸装置から41本ずつ二段とし、上段に対し下段のピッチを1/2ずらせ、各々のピッチを8.4mmで引揃えて二段とした。この際、

(13)

円柱体の振動数を300回/分、振幅を2〜12mmまで変化させ、他の条件は実施例3と同条件で開繊シート化を行なつた。その結果を表-2に示す。

表－2

振幅（mm）	厚み（mm）	目割れ	蛇行	毛羽
2	0.11	△	◎	◎
4	0.10	◎	◎	◎
6	0.10	◎	◎	◎
8	0.10	◎	◎	○
10	0.10	◎	○	○
12	0.09	◎	△	△

以上詳しく説明した通り、本発明方法は円柱体上においてヤーン等に円柱体軸方向の振動を与えつつ走行させて開繊するものであるから、ヤーン等はきわめて容易に開繊し、薄いシートが容易に得られる。また、各ヤーンの収束は良好で目割れ等も生じることなく安定なシートが

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得られ、水その他の液中で開繊すると更に容易になり、けば等は飛散することなく作業環境も良好になり、ヤーン等の張力が高い場合でも容易に開繊できる。また、溶液を選ぶと、サイジングの強い収束したヤーンにも適用でき、更に、この溶液として含浸樹脂液を用いると、単にその後、半硬化させるのみでプリプレグシートが得られる。また、ヤーン等は複数層に分けて開繊することができ、この場合は融合が強固になる。

4. 図面の簡単な説明

第1図は本発明方法を実施してプリプレグシートを製造する場合の装置の一例の配置図であり、第2図ならびに第4図はそれぞれ本発明方法でヤーン等を開繊する場合の斜視図であり、第3図はヤーン開繊時の張力分布の態様の一例を示す説明図、第5図は本発明方法で上下2層開繊する場合の側面図であり、第6図は第5図のA－A線上の断面図であり、第7図(a)ならびに(b)はそれぞれヤーンの収束態様の説明図である。

符号 1……ヤーン　2……給糸装置
3……整径装置　4……開繊装置
5……乾燥装置　6……巻取ロール
7……円柱体　8……合層ローラ
9……樹脂槽

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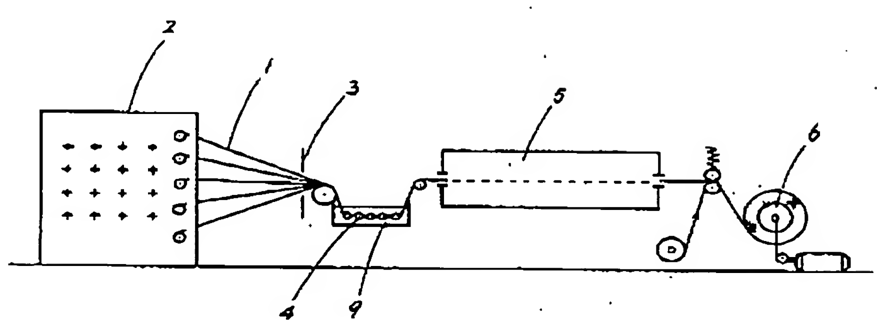
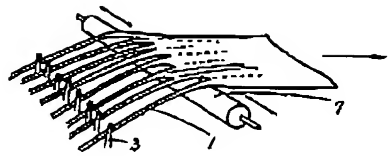
弁理士　[illegible]川[illegible]夫

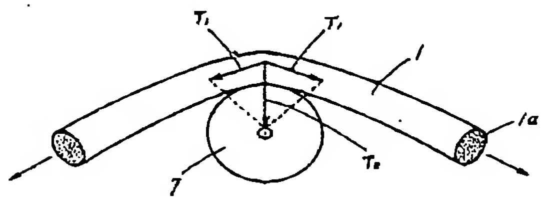
第1図



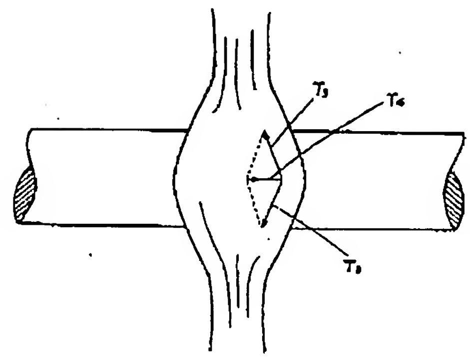
第2図



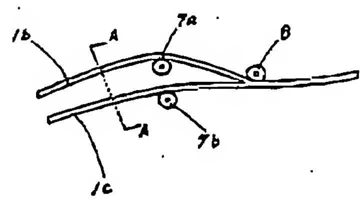
第3図



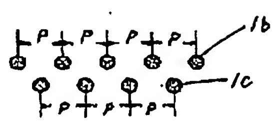
第4図



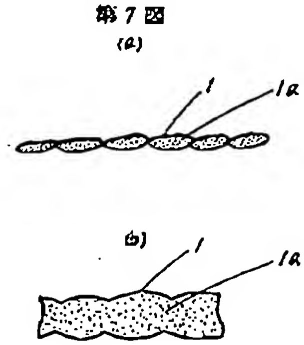
第5図



第6図



第7図



(English Translation of Japanese Patent Application Laid-open No.56-43435)

Method of spreading a multi-filament yarn and as such

WHAT IS CLAIMED IS:

Method of spreading a multi-filament yarn and so forth as continuously supplied by running said yarn and so forth on a cylindrical body vibrating in its axial direction.

DETAILED DESCRIPTION OF THE INVENTION

The invention relates to a method of spreading a multi-filament yarn and the like, in more details, pertaining to such method whereby such yarn and the like are thinly spread without causing fluffs thereon so as to be produced into a high-quality spread sheet with facility.

At present, such pre-impregnation sheet in which the component filaments are orderly aligned as being made from carbon fibers, glass fibers and so forth is put to use in various fields. This pre-impregnation sheet is produced by thinly spreading the respective multi-filament yarns and as such so as to be arranged into a sheet form and impregnating such sheet with a resin and tack drying the same impregnated with a resin. However, there is a problem with the prior method of spreading the respective yarns in order to produce a pre-impregnation sheet, in which it is hard to produce such sheet of high quality, thus, the improvement on such method being sought after.

Namely, such requirements shall be satisfied for being qualified as a high-quality pre-impregnation sheet referred to herein as having more than 100m in length and a thickness in the order of 0.1 mm with the component filaments aligned uniformly with each other. In some cases, it requires that the impregnability of a resin be lower. However, conventionally, friction, cohesion and so forth act upon the respective filaments, which makes it hard to spread the respective yarns thinly enough to be formed into a sheet, on the surface of which sheet the discontinuity between the adjoining spread yarns occurs seriously affecting its quality.

In view of the above inconveniences encountered with the

prior art, the invention is to provide a method of spreading a multi-filament yarn and the like whereby the respective yarns are spread thinly enough to be formed into a sheet with the respective filaments thereof commingled with each other without causing the discontinuity between the adjoining spread yarns on its surface.

That is to say, the invention is characterized in running the respective multi-filament yarns as continuously supplied on a cylindrical body vibrating in its axial direction so as to spread the respective yarns.

Hereafter, the invention is described in more details.

The invention is particularly effective for spreading such multifilament yarn as being made from carbon fibers, glass fibers so as to produce a pre-impregnation sheet, to which the invention is not limited, but may be applied to other multi-filament yarns generally distributed in the market.

Figure 1 shows one example of an apparatus for spreading the respective multifilament yarns into a sheet and impregnating the sheet with a resin so as to produce an pre-impregnation sheet. As shown, the respective yarns 1 are supplied to the spreading device 4 via the warping device 3 from the yarn supplier 2. At the spreading device 4 whose spreading operation is performed in the resin tank 9, the respective yarns 1 are spread thinly enough to be formed into a sheet and the sheet is impregnated with a resin and then fed to the drying chamber 5 so as to be tack dried, which pre-impregnation sheet is wound up by the wind-up roller 6.

The impregnation of a resin is performed, as shown in Figure 1, simultaneously with spreading operation by means of the spreading device 4 disposed in the resin tank 9, but the resin tank may be provided separately from the spreading device for performing the impregnation operation.

Then, upon performing spreading operation on the respective yarns 1 as supplied by means of the spreading device 4, as shown in Figure 2, they are spread while running on the cylindrical body 7 vibrating in its axial direction. This

enables the respective yarns to be spread well without either cohesion force or friction force acting upon the adjoining filaments, which results in forming an extremely thin pre-impregnation sheet.

That is to say, in the case of the yarn 1 being pulled up with the tensile force T_1 and supported on the cylindrical body 7 as shown in Figure 3, the cylindrical body is pushed back by the pressure T_2 applied by the yarn 1 while the rebound force having a value corresponding to that of the pressure T_2 acts upon the yarn 1. Thus, when the yarn 1 runs in contact with a part of the cylindrical body 7, it extends widthwise so as to be thinly spread by the action of the pressure T_2 and the rebound force T_2. However, once the yarn 1 extends widthwise, the force T_3 and T_4 act upon the respective filaments 1a, by the action of which force T_4 the yarn 1 is interrupted from extending widthwise and the friction force acts upon the adjoining filaments 1a along with the action of the cohesion force such as electrostatic force, Van der Waals force and so forth so that the yarn tends to become round in section.

In short, in the case of the respective yarns being spread in contact with a part of the cylindrical body 7, the respective yarns are spread to some extent by the tensile force applied thereto and the friction with the cylindrical body, but the degree to which the respective yarns are spread is not sufficient enough to be formed into a sheet. Besides, the interconnection and interengagement between the respective yarns are not sufficient so as to cause the discontinuity between the adjacent spread yarns on the surface of the sheet as formed. On the other hand, vibrating the cylindrical body 7 in its axial direction on which the respective yarns are placed or giving vibration crosswise with regard to the respective yarns cancels the dynamic relation between the respective filaments as mentioned above so that the respective yarns are spread in better condition so as to be thinly extended into a sheet. Vibration given crosswise to the respective yarns on the cylindrical body 7 is carried out in any manner, but normally

the cylindrical body 7 vibrates in its axial direction.

Further commenting, in order to overcome the dynamic relation between the respective filaments as shown in Figure 4 so as to spread the respective yarns, giving any kinds of vibration to the respective yarns, for instance, even giving vibration along with the feeding course of the respective yarns enables them to be spread successfully. However, such vibration as given to the respective yarns along with the feeding course thereof causes the respective yarns not to be intermingled with each other and to vulnerably raise fluffs on the surface of the respective yarns at the warping device. In the case of vibration being given widthwise with regard to the respective yarns, it keeps the respective yarns under a certain tension so that a sheet is formed with the respective spread yarns sufficiently intermingled with each other without any discontinuity between them and any fluffs or gaps on the surface thereof.

To note, vibration may be given crosswise to the respective yarns in water and synthetic resin solution and so forth besides being given in the air.

That is to say, vibration being given to the respective yarns placed on the cylindrical body in the air, the dynamic relation between the adjoining yarns is overcome so that the respective yarns are spread in better condition while they are by far more thinly spread in such solution as mentioned above because the cohesion and friction working between the respective filaments become smaller therein.

Furthermore, spreading operation being performed in such solutions as mentioned above, providing that fluffs occur on the spread sheet, there is no case where the fluffs scatter around. Moreover, such solution plays a role as a lubricant so that the degree to which the respective yarns are spread is increased and the respective spread yarns are intermingled with each other in better condition.

The respective yarns may be spread in two stages besides being spread in a single layer so as to be combined into a sheet.

Figure 5 shows the respective yarns spread in two stages

so as to be combined into a sheet. In this case, as shown in Figure 6, the respective yarns 1b and the respective yarns 1c are spread in different stages so as to be combined into a sheet. In the case where the respective yarns 1b are supplied with an interval P between them, the respective yarns 1c aligned in the lower stage are supplied with the displacement by one-half multiplied by the pitch P from the upper yarns 1b. The respective yarns 1b and 1c are spread on the respective cylindrical bodies 7a and 7b, which bodies vibrate in their axial direction in the same way as described above. The respective spread yarns 1b in the upper stage and those 1c in the lower stage are intermingled with each other so as to be combined into a sheet without intermittence.

That is to say, upon the respective yarns 1b and 1c being spread on the cylindrical body 7, they are spread thinly as shown in Figure 7(a) in the beginning, but the force T_4 as shown in Figure 4 works on a spread portion of the respective yarns so as to tend to hamper them from being widthwise extended. However, the respective spread yarns 1b and 1c are partly overlapped one over another and intermingled with each other so that such force T_4 working on a spread portion of the respective yarns is set off against each other, thereby, the respective spread yarns continuing without intermittence as shown in Figure 7(b).

Besides the yarns arranged in a plurality of stages being overlaid one over another, vibration being given crosswise with regard to the respective yarns arranged in a single stage and placed on the cylindrical body 7, the adjoining spread yarns are intermingled with each other so that the force T_4 working on a spread portion of the respective yarns is set off against each other, thereby, the respective spread yarns continuing without intermittence. To note, following that spreading operation is complete in the respective stages, the upper and lower spread yarns are overlaid at an influx roller 8 as shown in Figure 5.

The best mode conditions for carrying out the invention are as follows.

(1) Vibrations

Vibration is reciprocally given crosswise to the respective yarns placed on the cylindrical body within the range of 30 to 3000 times per minute. Increasing the number of vibrations is desirable for enhancing the degree to which the respective yarns are spread, but increasing the same too much causes fluffs to occur on the surface of the respective spread yarns. In this respect, the maximum number of vibrations should be in the order of 3000 times. Where the number of vibrations is reduced to less than 30 times, no spreading effect is brought at all. In the case of carbon fibers yarn being spread, favorably, the number of vibrations should be in the order of 300 to 600 times per minute.

(2) Length by which the cylindrical body moves back and forth in its axial direction and the feeding speed of the respective yarns

The larger the length becomes, the less spreading effect improves. Besides problems occur related to the equipment cost. Thus, preferably, vibration is given thereto over the range of 1 to 10 mm while the feeding speed of the respective yarns should be in the order of 30 to 150 m per hour.

To note, the cylindrical body is disposed such that it is rotatable, but may be fixed instead for playing its role.

The examples of the invention are described as follows.

EXAMPLE 1

Eighty-six E glass roving yarns whose linear density of fibers is 310 Tex equivalent to 2800 denier are suspended to the yarn supplier. The respective yarns are led to the spreading device with the feeding speed of 100 m/hour and the tensile force of 20g applied thereto and with an interval 4 mm between them. The respective yarns are spread into a sheet having 340 mm in width by moving the cylindrical body back and forth in its axial direction over 25 mm to give 400 vibrations per minute to the respective yarns.

Observing a sheet as spread that is sandwiched between two glass plates, it is found to be free from fibrous sinuosity and

unevenness on the surface and has 0.05 mm in thickness. Cutting off both ends of the sheet as sandwiched between those plates and taking them off, there is no case where the adjoining spread glass roving yarns are separated from each other.

EXAMPLE 2

Forty-three E glass roving yarns like the example 1 are supplied from the respective yarn suppliers to the cylindrical body of the upper and lower stages respectively. The respective yarns of the respective stages are drawn out from the respective yarn suppliers with an interval of 8 mm between them. The interval between the adjoining yarns lined in the lower stage is displaced by one-half pitch from that between the respective yarns lined in the upper stage. Under the same conditions of the feeding speed of the respective yarns, the tensile force applied thereto, the number of vibrations and the length by which the cylindrical body moves back and forth in its axial direction as Example 1, a sheet of 340 mm in width and 0.05 mm in thickness is formed. Observing the sheet as spread that is sandwiched between two glass plates, it is found to be as neat as that formed in the example 1. Cutting off both ends of the sheet sandwiched between those glass plates and removing the plates from it, it stands perfect and the respective spread yarns intermingled with each other are not easy to be separated even though they are pulled sideways.

To note, in comparison with the above examples, the respective glass roving yarns being spread into a sheet without vibrating the cylindrical body, they seem to be flattened out in contact with the cylindrical body, but the respective spread yarns are converged into a bundle after the passage of the cylindrical body without the respective spread yarns being intermingled with each other, failing in being formed into a sheet.

EXAMPLE 3

Eighty-two carbon multi-filament yarns respectively comprising 6000 filaments whose linear density of fibers is defined 4000 denier are suspended to the yarn supplier, to which

yarns respectively the tensile force of 50g is applied and which respective yarns are fed to the cylindrical body vibrating crosswise with regard to the feeding course of the respective yarns at the feeding speed of 100 m/hour with an interval of 4.2 mm between them so as to be spread into a sheet.

In this example, a resin solution prepared by solving 100 parts of epoxy resin in 100 parts of methyl ethyl ketone, to which solution a curing agent (BF_3) corresponding to 5% of the total volume is added, is contained in the spreading device. The cylindrical body moves back and forth over 5 mm in its axial direction and vibrates by 0 to 3000 times per minute, which result is shown in Table 1.

Table 1

Vibration (times/min.)	thickness (mm)	Gap	Sinuosity	Fluffs
0	0.18	Frequent Occurrence	None	None
30	0.11	3	None	None
100	0.10	0	None	None
300	0.10	0	None	None
1,000	0.10	0	Acceptable	Acceptable
2,000	0.10	0	Possible	Possible
3,000	0.10	0	No good	No good

Gap: the number of defects having more than 0.1 mm in width and 30 mm in length per 1 m^2 of the sheet observed with light transmitted through the sheet.

EXAMPLE 4

Forty-one carbon multi-filament yarns having the same property as that used in the above example 3 are supplied from the respective upper and lower suppliers to the respective cylindrical bodies. The respective yarns arranged in the lower stages are displaced by one-half pitch from the corresponding yarns in the upper stage. The respective yarns in each stage

are lined with an interval of 8.4 mm between them. The respective cylindrical bodies vibrate by 300 times per minute and move back and forth over 2 to 12 mm in length in their axial direction, and the other conditions are the same as those of the above example 3, which result is shown in Table 2.

Table 2

Length (mm)	Thickness (mm)	Gap	Sinuosity	Fluffs
2	0.11	Acceptable	None	None
4	0.10	None	None	None
6	0.10	None	None	None
8	0.10	None	None	Acceptable
10	0.10	None	Acceptable	Acceptable
12	0.10	None	Possible	Possible

As described above, the method according to the invention is intended for spreading the respective yarns and as such running on the cylindrical body moving back and forth in its axial direction so as to subject the same to vibrations whereby the same is spread with facility so as to be formed into a thin sheet without difficulty. The respective spread yarns are intermingled with each other without causing any gap between them so that a sheet with stable quality is obtained. Where the same is spread inside water or other liquids, the operation is further facilitated without scattering around fluffs so as to improve the job environment and a yarn to which higher tensile force is applied is spread with ease. Depending upon the selection of the solution, the operation is performed on such yarn as the respective filaments thereof being firmly bonded together with a sizing agent. When an impregnation resinous solution is put to use, a pre-impregnation sheet is obtained just with tack drying the same. Further, the respective yarns are spread in a plurality of stages so as to be combined, which intensifies the bonding between the respective filaments of a

sheet.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows the arrangement of one example of an apparatus for producing a pre-impregnation sheet according to the invention; Figures 2 and 4 are perspective views to comparatively show the state where the respective yarns are spread according to the invention and according to the prior art; Figure 3 shows one example of how the tensile force applied to the respective filaments is dispersed in contact with the cylindrical body; Figure 5 is a side view to show an example wherein the respective yarns are spread in the respective upper and lowers stages according to the invention; Figure 6 is a sectional view taken along A-A line of Figure 5;and Figure 7 (a) and (b) show the respective spread yarns intermingled with each other.